A THERMAL HYPERSPECTRAL CUBESAT CONCEPT FOR LUNAR EXPLORATION. C. M. Ferrari-Wong[1], P. G. Lucey[1], R. Wright[1], and M. A. Nunes[1,2], [1]Hawaii Institute of Geophysics and Planetology, University of Hawaii at Manoa, HI 96822, [2]Hawaii Space Flight Laboratory, University of Hawaii at Manoa, HI 96822 (cferrari-wong@higp.hawaii.edu).

Introduction: NASA's Earth Science Technology Office InVEST program has funded the Hyperspectral Thermal Imager (HyTI), a 6U CubeSat equipped with a thermal infrared (TIR) hyperspectral imager for terrestrial science applications with a planned launch in 2021. The HyTI Hyperspectral Imager instrument is currently being designed and developed by the Hawaii Spaceflight Laboratory and the Hawaii Institute of Geophysics and Planetology (HIGP). Thermal infrared spectroscopy is a powerful tool for characterizing the surfaces of objects in the inner solar system and would also be highly applicable to lunar science.

Instrument: The HyTI Hyperspectral Imager (HSI) is based on the Fabry-Perot Interferometer principle with a "no moving parts" design (Figure 1). It will deliver 25 spectral channels in the range of 8-10.7 microns. The instrument detector is a JPL BIRD TIR Focal Plane Array (FPA). BIRD imagers have high uniformity, low cost, low noise, and higher operating temperatures than previously-flown TIR FPAs. The same instrument is ideally suited for lunar science, covering wavelengths that include important lunar spectral phenomenology.

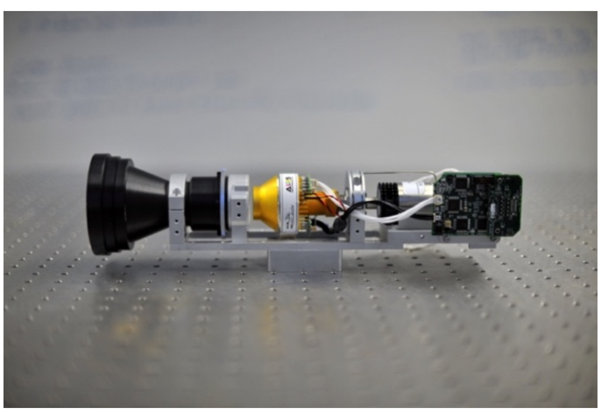

Figure 2. HIGP Fabry-Perot LWIR Hyperspectral imaging interferometer, a predecessor of the HyTI HSI [1].

Science: Between 5 to 50 microns, major rock-forming silicates and other minerals that compose the surfaces of inner solar system objects exhibit unique vibrational spectral signatures. Among these spectral features is a peak in thermal emission called the Christiansen Feature (Figure 2). This feature occurs near a wavelength where the real index of refraction of the mineral passes through unity, a wavelength shorter than the fundamental infrared vibrational features associated with each mineral. There the spectral emissivity of the surface peaks, and as its position is correlated with the position of the associated fundamental vibration. The position of this emission maximum contains diagnostic information regarding the minerals present, as it is correlated with the average silica content of minerals [2].

Highly transparent iron-poor silica-rich minerals and glasses are diagnostic materials of evolved rock types identified in the lunar returned sample collection, but are not directly perceptible to near-IR spectroscopy. However, thermal infrared spectroscopy using the Christiansen Feature is sensitive to both these materials, and can provide an independent estimate of the more common lunar silicates. The only extensive TIR data for lunar surface compositions are three band multispectral data collected by the Diviner Lunar Radiometer on the Lunar Reconnaissance Orbit. While it has made important discoveries, data are limited by the small number of bands. Hyperspectral data would enable unambiguous detection and characterization of high silica minerals and phosphates important for lunar resource utilization.

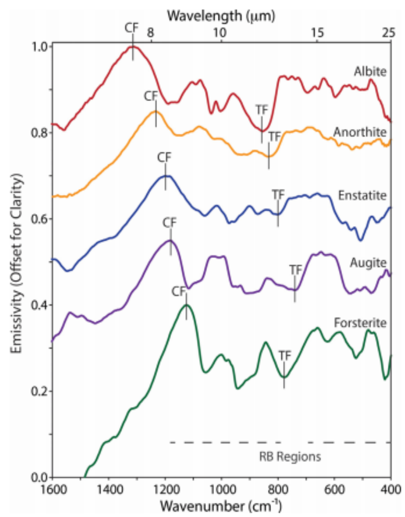

Figure 1. Laboratory spectra of silicate minerals showing the Christiansen Feature (CF) for typical lunar minerals [3].

The instrument will also measure the time of day variations in the temperature of the lunar surface at high spatial and time resolution for thermophysical studies. This capability could determine rock abundances at landing sites and porosity of the surface useful for estimating geotechnical properties for exploration [4].

References: [1] Lucey P.G., Akagi J. In Algorithms and Technologies for Multispectral, Hyperspectral, and Ultraspectral Imagery XVII 2011 May 20 (Vol. 8048). International Society for Optics and Photonics. [2] Logan L.M., Hunt G.R., Salisbury J.W., Balsamo S.R. JGR. 1973 Aug 10;78(23):4983-5003. [3] Hanna K.D., et al. Icarus. 2017 Feb 1;283:326-42. [4] Hayne P.O., et al. Journal of Geophysical Research: Planets. 2017 Dec 1;122(12):2371-400.